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GB 1287190 A GB 1262749 A GB 1006686 A
EP 0187392 A1

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(54) Sensing the condition of a sample of food

(57) A method of sensing the condition of a sample of food comprises applying a sinusoidal a.c. current or voltage to the sample at a frequency of between 100kHz and 1MHz and measuring the phase angle of the impedance of the sample at this frequency. The phase angle is measured by coupling the impedance of the sample and that of a reference impedance alternately to one input of a phase comparator the other input of which is coupled to the a.c. current or voltage source. Conditions such as whether the food has been frozen then thawed or is fresh can be sensed using the method. A device is described which uses the method, needs no calibration, and is accurate to two tenths of a degree.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

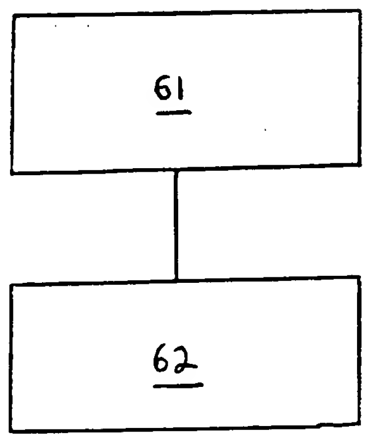

FIGURE 1

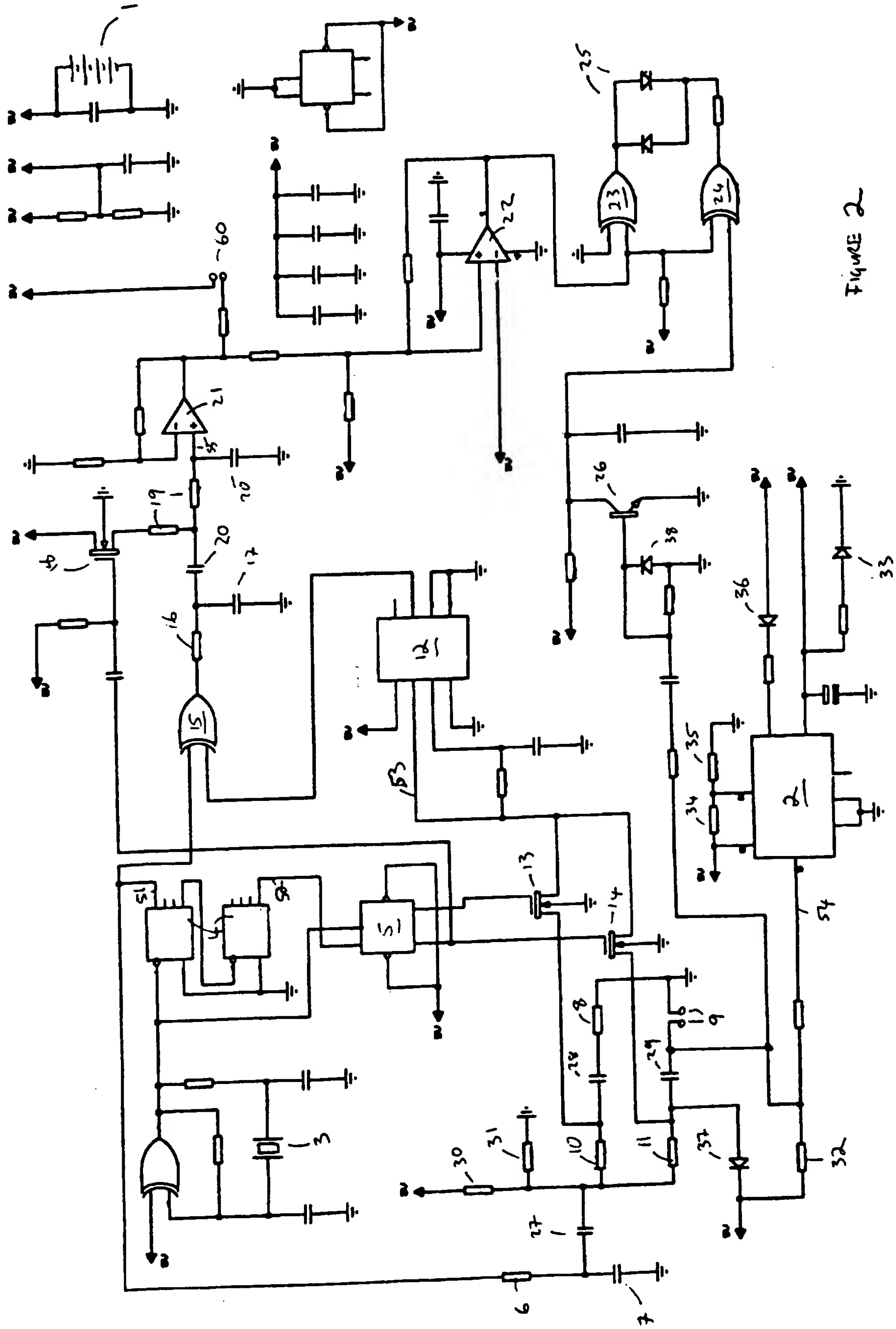

FIGURE 2

A METHOD OF SENSING THE CONDITION OF A SAMPLE OF FOOD

This invention relates to a method of sensing the condition of a sample of food, comprising applying an a.c. current or voltage to the sample at a given frequency and measuring the phase angle of the impedance of the sample at the given frequency. The invention also relates to a device for sensing the condition of a sample of food.

A known method for measuring the freshness of fish is described in GB-1262749. In this method the phase angle of an a.c. voltage developed between probes on a food sample is compared with the phase angle of an a.c. voltage developed across a reference resistor in series with the probes by using a phase-sensitive detector circuit. A sinusoidal voltage at a frequency of 2 kHz is used in this method. The impedance of fish in this frequency regime is sensitive to the time post mortem - i.e. the amount of spoilage.

This known method has a number of drawbacks. The method appears to be very sensitive to the type and size of fish and the position on the fish where the measurement is made. Moreover, reliability and reproducibility of results can be adversely affected by the quality of electrical contact to the fish. Further, the method cannot,it is believed, be used to discriminate between fresh fish and that which has been frozen then thawed, and foods other than fish cannot be tested reproducibly using the above method. Finally the apparatus employed is expensive to manufacture.

It is an object of the present invention to enable the above disadvantages to be mitigated.

According to a first aspect of the invention, there is provided a method as defined in the first paragraph above, characterized in that the given frequency is in the range 100 kHz to 1 MHz. Preferably the a.c.current or voltage waveform is substantially sinusoidal. This arrangement can give the advantage that other foods can be sensed in addition to fish, and the sensing is not so sensitive to contact resistance. Also other food conditions, such as whether the food has been frozen then thawed or is fresh, can be sensed using the above method.

The phase angle is conveniently measured by coupling the impedance of the sample and of a reference impedance alternately to one input of a phase comparator, the other input of which is coupled to the a.c. current or voltage being applied, the alternation occurring at a frequency lower than the given frequency. This can give the advantage of

enabling a simple circuit having an accuracy of phase angle measurement approaching a tenth of a degree to be used.

According to a second aspect of the invention, there is provided a device for sensing the condition of a sample of food, the device comprising a plurality of electrodes for engaging a sample of food, a source of a.c. current or voltage at a given frequency in the range 100 kHz - 1 MHz, a phase comparator having one input coupled to a test impedance and the other input coupled to the source of a.c. current or voltage, a reference impedance, and switching means being constructed to alternate the test impedance between the reference impedance and the impedance of a sample of food, the frequency of alternation being lower than the given frequency, thereby measuring the phase angle of the impedance of the sample of food. Preferably the a.c. current or voltage has a substantially sinusoidal waveform.

Preferably, the device is placed in a condition in which its power consumption is reduced when the electrodes for engaging a sample of food are not in engagement with an electrically conductive surface. This can increase battery life if the device is run from a battery.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:-

Figure 1 shows a flow diagram of a method according to the invention, and

Figure 2 shows a circuit diagram of a device for putting the method into effect.

In figure 1, a method according to the invention is shown as a flow diagram comprising a series of numbered blocks. The blocks have the following significances. The first step, represented by block 61, denotes applying an a.c. current or voltage to the sample at a given frequency. The second step, represented by block 62 denotes measuring the phase angle of the impedance of the sample at the given frequency. In the present example the given frequency is approximately equal to 280 kHz, although a given frequency in the range 100 kHz to 1 MHz can be employed if desired. The given frequency is a single frequency (which is typically in the in the range 100 kHz to 600 kHz for meat such as beef), and the waveform applied to the sample is substantially sinusoidal. The phase angle is measured by coupling the impedance of the sample and of a reference impedance alternately to one input of a phase comparator, the other input of which is

coupled to the a.c. current or voltage being applied, the alternation occurring at a frequency lower than the given frequency.

The device shown in Figure 2 is designed to measure the phase angle of the impedance of samples of meat or fish at a frequency of approximately 280 kHz. The components of the circuit shown in this figure are itemized in the following Table 1.

TABLE 1

Ref Numeral	Component	Part Number	Supplier/Value
1	Battery	PP3	9V
2	IC	MAX 667	Maxim
3	Resonator	N/A	560 kHz
4	IC	74HC393	Motorola
5	IC	74HC74	Motorola
6	Resistor	N/A	70 Ω
7	Capacitor	N/A	1 nF
8	Resistor	N/A	330 Ω
10	Resistor	N/A	2.2 kΩ
11	Resistor	N/A	2.2 kΩ
12	IC	MAX 909	Maxim
13	Transistor	5D211	Philips
14	Transistor	5D211	Philips
15	IC	74HC86	Motorola
16	Resistor	N/A	4.7 kΩ
17	Capacitor	N/A	2.2 nF
18	Transistor	5D211	Philips
19	Resistor	N/A	4.7 kΩ
20	Capacitor	N/A	220 nF
21	IC	LM392	NS
22	IC	LM392	NS
23	IC	74HC86	Motorola
24	IC	74HC86	Motorola
25	LED	264-398	Farnell
26	Transistor	BF495	Philips
27	Capacitor	N/A	10 nF
28	Capacitor	N/A	220 nF
29	Capacitor	N/A	270 nF
30	Resistor	N/A	150 kΩ
31	Resistor	N/A	22 kΩ
32	Resistor	N/A	470 kΩ

TABLE 1 (continued)

33	LED	264-374	Farnell
34	Resistor	N/A	10 MΩ
35	Resistor	N/A	2.7 MΩ
36	LED	264-362	Farnell
37	Diode	IN4244	
38	Diode	IN4244	

Although the device is powered by a 9 volt PP3 battery (1), virtually all of the circuitry is driven from a +5 volt regulator integrated circuit (2). This circuit continues to operate stably until the battery voltage falls to below +6 volts.

The top left hand corner of the circuit diagram shows a standard oscillator configuration. The frequency reference is a 560 kHz ceramic resonator (3), chosen for low cost, which oscillates at twice the measurement frequency. Its output frequency is divided by 2 by an integrated circuit (4) to give the measurement frequency of 280 kHz at output 51, and is divided by a further 128, also by integrated circuit 4 to give the chopping or alternating frequency of 2.2 kHz at output 52. The chopping frequency, which is the frequency at which the phase of the sample impedance is compared with the reference impedance, is latched by an integrated circuit (5) to give complimentary outputs Q and -Q.

The measurement frequency square wave from integrated circuit 4 is filtered by a resistor 6 and a capacitor 7, to make it relatively sinusoidal. A reference impedance is provided by a resistor 8, to be compared with the impedance of the sample which is provided between the meat contacting electrodes 9. The sinusoidal measurement signal is coupled via resistors 10 and 11, which, because of their much higher impedance, act like current sources.

The two signal voltages, from the sample and from the reference impedance, are coupled alternately to an input 53 of an integrated circuit comparator 12 at the chopping frequency, via switching transistors 13 and 14. These transistors are chosen to have low capacitance and low on-resistance. When either signal voltage is connected, the comparator switches at the zero crossing points of the 280 kHz measurement frequency. This comparator therefore acts as a hard limiter. Overall circuit timings are arranged so that these zero crossings happen when nothing else in the circuit is switching, to minimize the possibility of interference.

The output of the comparator is exclusive OR-ed with the measurement frequency in integrated circuit 15. The exclusive OR function is well known to give an averaged output voltage proportional to the input phase angle. The exclusive or function is not however essential for the operation of the phase comparator, and phase comparators using other logic functions may be used if desired. Resistor 16 and capacitor 17 filter out the measurement carrier and harmonics, leaving a low frequency square wave, at the chopping frequency, whose amplitude is proportional to the phase difference between the sample

signal and the reference signal. Switch 18 clamps its drain voltage to a 3 volt reference level, at the chopping frequency, when the sample is being sensed. Thus, the average signal on the drain of transistor 18 is different from 3 volts by an amount proportional to the phase difference being detected. Resistor 19 and capacitor 20 filter out the chopping frequency component, so that the signal on input 55 of integrated circuit 21 is a d.c. voltage, which is amplified by the integrated circuit labelled 21. Amplifier gain is chosen to give an output of 100 mV per degree of the phase shift at an analogue output (60) for a voltmeter.

The reference voltage is chosen as +3 volts so that the output of 21, when referred to +3 volts, can go more negative than positive, consistent with the range of phases likely to be measured from samples of meat. Integrated circuit 22 is a comparator which switches when the output of 21 crosses +3 volts, in other words when the phase difference is zero. This corresponds to a zero gradient of the admittance/frequency graph at 280 kHz. The output of the comparator, via buffer 23 and invertor 24, drives an LED (25) labelled "Fresh/Thawed", which changes colour when the comparator changes state. However, 24 only acts as an invertor when switching transistor 26 is turned off. Otherwise, with 26 on, 24 acts as a buffer, and LED 25 does not light. The switch 26 is turned on if there is an excessive a.c. voltage across the sample electrodes, indicating a bad contact with the sample. As a result, the fresh/thawed indicator is only active when proper contact has been made.

Capacitors 27, 28 and 29 allow independent d.c. voltages to exist at switches 13 and 14 and on the meat engaging electrodes 9. The d.c. level at switches 13 and 14 is set by the voltage divider (30 and 31) to be approximately 0.65 V. This is chosen to ensure that there is enough gate drive to turn on the switches 13 and 14, whilst ensuring that the signal on the electrodes 9 does not go too far below that of the ground potential thereby causing substrate conduction in the switching transistors.

The d.c. voltage on the electrodes 9 is used to switch the circuit on and off. If the electrodes are not in contact with a conductive surface, resistor 32 pulls the ungrounded electrode to a potential of +9V, with the result that integrated circuit 2 shuts down, thereby disconnecting the circuit. When the electrodes are in contact with a conductive surface, input 54 of 2 is pulled to 0V, thereby turning the +5V supply on. Integrated circuit 2 is a + 5V voltage regulator (max667) having voltage detection giving the ability to be

shutdown by changing the voltage on input 54. Since the +5V supply is energized whenever a conductive sample such as meat is contacted by the electrodes, an LED (33) labelled "contact" is driven directly from the +5V line. Resistors 34 and 35 set an "undervoltage" LED (36) to light when the battery voltage falls below +6V which reminds the operator to insert a fresh battery.

The circuit has no adjustments. Worst case accuracy is expected to be better than 1 degree, and best case accuracy will be better than 0.2 degree. A number of different effects contribute to phase errors. These include capacitance across the sample engaging electrodes including the capacitances of diodes 37, 38 and transistor 26; charge injection via the gates of 13 and 14; matching of capacitors 28 and 29; hysteresis in the comparator 12; amplitude dependent delays in 12; source impedance dependent delays in 12, and input offsets in integrated circuit 21. In any given circuit the phase error will be stable, although it will change if the sample impedance changes.

The measured impedance characteristics of meat are such that a.c. currents or voltages which are not sinusoidal and therefore have a harmonic content can be used instead of a substantially sinusoidal waveform with little effect on the measurement accuracy.

In summary, a method of sensing the condition of a sample of food is described, the method comprises applying an a.c. current or voltage to the sample (typically a sinusoidal waveform at a frequency between 100 kHz and 1 Mhz or between 100 kHz and 600 kHz) and measuring the phase angle of the impedance of the sample at the this frequency. The phase angle is measured by coupling the impedance of the sample and that of a reference impedance alternately to one input of a phase comparator, the other input of which is coupled to the a.c. current or voltage source. A variety of foods can be sensed in addition to fish, and the sensing is less sensitive to contact resistance. Conditions such as whether the food has been frozen then thawed or is fresh can be sensed using the method. A device is described which uses the method, needs no calibration, and is accurate to two tenths of a degree.

CLAIMS

1. A method of sensing the condition of a sample of food, comprising applying an a.c. current or voltage to the sample at a given frequency and measuring the phase angle of the impedance of the sample at the given frequency, characterized in that the given frequency is in the range 100 kHz to 1 MHz.
2. A method as claimed in claim 1 in which the a.c. current or voltage waveform is substantially sinusoidal.
3. A method as claimed in claim 1 in which the phase angle is measured by coupling the impedance of the sample and of a reference impedance alternately to one input of a phase comparator, the other input of which is coupled to the a.c. current or voltage being applied, the alternation occurring at a frequency lower than the given frequency.
4. A method as claimed in claim 1 in which the condition being sensed is whether the sample of food is fresh or has been frozen then thawed.
5. A method substantially as described herein.
6. A device for sensing the condition of a sample of food, the device comprising a plurality of electrodes for engaging a sample of food, a source of a.c. current or voltage at a given frequency in the range 100 kHz - 1 MHz, a phase comparator having one input coupled to a test impedance and the other input coupled to the source of a.c. current or voltage, a reference impedance, and switching means being constructed to alternate the test impedance between the reference impedance and the impedance of a sample of food, the frequency of alternation being lower than the given frequency, thereby measuring the phase angle of the impedance of the sample of food.
7. A device as claimed in claim 6 in which the a.c. current or voltage has a substantially sinusoidal waveform.
8. A device as claimed in claim 6 in which the device is placed in a condition in which its power consumption is reduced when the electrodes for engaging a sample of food are not in engagement with an electrically conductive surface.
9. A device as claimed in claim 6 in which the condition being sensed in use is whether the sample of food is fresh or has been frozen then thawed.

10. A device substantially as described herein.

Amendments to the claims have been filed as follows

1. A device for measuring the phase angle of a sample impedance, the device comprising a plurality of electrodes for engaging a sample, a source of a.c. current or voltage at a given frequency in the range 100 kHz - 1 MHz, a phase comparator having one input coupled to a test impedance and the other input coupled to the source of a.c. current or voltage, a reference impedance, and switching means being constructed to alternate the test impedance between the reference impedance and the impedance of a sample, the frequency of alternation being lower than the given frequency, thereby measuring the phase angle of the impedance of the sample.
2. A device as claimed in claim 1 in which the a.c. current or voltage has a substantially sinusoidal waveform.
3. A device as claimed in claim 1 in which the device is placed in a condition in which its power consumption is reduced when the electrodes for engaging a sample are not in engagement with an electrically conductive sample.
4. A device for measuring the phase angle of a sample impedance substantially as described herein.

The Patent Office

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Application No:	GB 9505002.7	**Examiner:**	Mr A Oldershaw
Claims searched:	1 to 10	**Date of search:**	24 May 1995

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): G1N NCCA, NCCE, NCCJ, NCCX, NCXB, NCXC, NCXX

Int Cl (Ed.6): G01N

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB1287190	(N.R.D.C.)	1,2 at least
Y	GB1262749	(N.R.D.C.)	1,2 at least
Y	GB1006686	(DETHLOFF) - see p. 2 ll. 38-42,56-60	1,2 at least
Y	EP0187392A1	(RAFAGNATAEKNI)	1,2 at least

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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